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Adenosine triphosphate measurements for real-time monitoring of microbial drinking water quality

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Today microbial drinking water quality is monitored through random sampling. Current standard methods are often culture based. These are often time consuming and results are usually not available until 2 to 3 days after sampling. This means that contaminated water may be consumed before the results are available. Furthermore, contaminations of short duration are most likely to pass undetected due to the low sampling frequency.

An alternative approach may be continuous sampling combined with a real-time analysis such as adenosine triphosphate (ATP) measurements, which could significantly improve the surveillance of microbial drinking water quality, especially for water supplies which distribute drinking water without a disinfectant residual as e.g. in Denmark. The aim of this study was to investigate the potential of the ATP-method for continuous monitoring of microbial drinking water quality, with focus on comparing this methods response and sensitivity to other standard methods when drinking water is contaminated with waste water.

In batch experiments raw waste water was diluted to 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} and 10^{-7} in drinking water. Microbial ATP concentrations were measured indirectly, i.e. total ATP was measured by adding an extraction reagent (cell lysis) and then luciferine/luciferase (Celsis LuminEX/LuminATE). Non-microbial ATP was measured by adding luciferine/luciferase alone. All samples were also analyzed using traditional microbiological methods: heterotrophic plate counts ($HPC_{Yeast,22°C,72\ hours}$ and $HPC_{Yeast,37°C,48\ hours}$), Colilert-18 (*E. coli* and coliforms) and total direct counts (DAPI staining).

The simulated waste water contamination was clearly detected at 10^{-3} dilution in drinking water with ATP measurements (40.2 pg ATP/ml), whereas the ATP concentration was 6.4 pg ATP/ml in non-contaminated drinking water. With direct total cell counts it was possible to detect waste water diluted to 10^{-3} ($2.16x10^5$ cells/ml) as opposed to $1.17x10^5$ cells/ml in non-contaminated drinking water. CFU per ml decreased with increasing dilution of waste water when measured as HPC 22°C and HPC 37°C, though the drinking water guideline criteria of 200 and 20 CFU/ml, respectively, were met at dilutions higher than 10^{-5} of waste water. Colilert-18 could detect both coliforms (7 MPN/100 ml) and *E. coli* (2 MPN/100 ml) in 10^{-7} dilution of waste water in drinking water, thus exceeding the other methods in sensitivity. The sensitivity of the ATP method was increased to 10^{-5} diluted waste water when the experimental set-up was incubated at 10°C for 6 days, due to aftergrowth caused by additional substrate from the waste water contamination. Applying more sensitive reagents for the ATP-method did not improve the sensitivity of the method, since the ATP level of the contaminant was diluted to the ATP level of the specific drinking water, meaning that the sensitivity of the ATP method depends on both contamination load and load of indigenous bacteria in drinking water.

ATP can be used as an early warning tool, especially in the period when the contamination concentration is high - and may also be applicable to detect pulse contaminations. The sensitivity of the ATP method depends on the microbial load of contaminant and the Colilert-18 on the presence of indicator bacteria (*E. coli* and coliforms). This distribution will differ depending on type of contaminant and the decay of the indicators; hence the experiment was repeated for other types of contaminations such as surface water.